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Extending the NEC Concept

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## **Extending the NEC Concept**

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### **Abstract**

The concepts for NEC, which are very closely aligned with the NCW tenets and framework, have been generated over the past two years and are now being used to investigate future military capability. In the main these investigations have been concerned with command and control. However, of late some inquiries have originated from sources whose systems are totally automated and are at the one of the ends of a sensor to shooter chain.

The current NEC Themes, the encapsulation of the NEC concept, and the published NEC Benefits Chain, have been unable to fully support these inquiries. Whilst the lower levels of the NEC Themes directly supported the inquiry, those of better networking and better information sharing, the higher order themes, particularly Shared Understanding had little applicability to the inquirers. This was due to the very human/cognitive nature of these themes.

A new Theme, concerned with the equivalent of 'sharing understanding' between automated machines, is added to the existing NEC Themes and the NEC Benefits Chain is totally re-written to include the concepts of Individual Machine 'understanding' and sharing it between many machines.

## **Background**

The concepts for Network Enabled Capability (NEC), which are very closely aligned with the Network Centric Warfare (NCW) tenets and framework, have been generated over the past two years and are now being used to investigate future military capability. In the main these investigations have been concerned with command and control. However, of late some inquiries have originated from sources whose systems are totally automated and are at the one of the ends of a sensor to shooter chain.

The current NEC Themes [1], the encapsulation of the NEC concept, and the published NEC Benefits Chain [1], have been unable to fully support these inquiries. Specifically, the inquiries were to investigate the impact of NEC on the future design of:

- Seeker Heads.
- Uninhabited Air Vehicles (UAVs).
- Air-launched weapon systems.

The common theme to all these inquiries, and what made it so difficult to employ the existing NEC Concept, is that they relate to systems that have no human content.

These inquiries initiated work to extend the concepts underpinning NEC to include automated systems, groups of interworking automated systems and automated systems and humans interworking.

The aim of this paper is to describe the result of the work to investigate the extension of the NEC Concept.

Currently, the two definitions of the NEC concept are the NEC Themes and the NEC Benefits Chain. Both are very human centric and have provided minimal support to understanding the impact of NEC on the types of inquiries mentioned above. The work reported in this paper has used the inquiries as use cases to identify how the Themes and Benefits Chain should be extended. For brevity, this paper describes only a single use case: the impact of NEC on the design of an air-launched weapon system.

## **Structure of Paper**

Following this introductory section, this paper has four sections:

- A brief explanation of where NEC has come from and description of two critical ways of conveying the NEC Concept: the Themes and the Benefits Chain.
- A presentation of the extended NEC Concept.
- The application of the extended NEC Concept to one of the problems outlined in the introduction.
- Conclusions.

## **A Background to NEC**

NEC is the latest in a number of UK digitization initiatives [2] from the Defence Operational Command Information System Study (DOCISS) and the Joint Command System Initiative (JCSI), both of which defined a single approach to the specification and implementation of operational level CIS, through the land digitization initiative, Digitization of the Battlefield Land (DBL), to the Joint Battlespace Digitization initiative (JBD). JBD shared a lot of the aspirations with NEC: in particular the provision of an infrastructure upon which ALL battlespace systems would reside and intercommunicate. The underlying premise of JBD was to use the infrastructure to ensure that '...the right information got to the right place at the right time...'. NEC has taken this vision one stage further and, feeding off the Network Centric Warfare (NCW) initiative in the United States (US), realised that such information provision could revolutionise the way military operations are conducted. In particular, the concept of network-centricity, where individual platforms no longer provide all their own sensors, decision-makers and weapon systems necessary to do a task. Rather, the network provides the necessary information from any available source, to decision-makers distributed about the battlespace who use the most appropriate effectors for the job. The assumption being that such a network-centric approach would enable a much more flexible and agile force, capable of reacting more efficiently and effectively, particularly in quickly changing environments.

One of the few, significant ways in which the NCW and NEC approaches differed is how systems under these initiatives are acquired. Under NCW the mantra is 'transformation' – a major leap in capability towards the aspirations of NCW in a single acquisition cycle. In the UK the mantra is 'evolution' – a journey towards the vision accomplished over a number of acquisition cycles. This difference in approach is based upon the UK requirement to keep to within, or as near to as practical, the current defence budgetary estimates [3].

The NEC Concept is encapsulated at a high level in two diagrams; the NEC Themes and the NEC Benefits Chain.

### **The NEC Themes**

The NEC Themes are an attempt to capture the unique nature of an NEC force. Like the description of a London bus that says nothing about what a bus is (it is red, contains a jolly cockney conductor and always comes in threes) so the NEC Themes say nothing about what a military force is; it assumes this is known and it only presents the unique NEC aspects of it.

The NEC Themes are based upon the characteristics of an NCW force [4].

These were brainstormed, shown at figure 1, to provide a richer picture and then grouped into six Themes. (In fact there are seven but the last one, relating to acquisition has been omitted from this discussion.

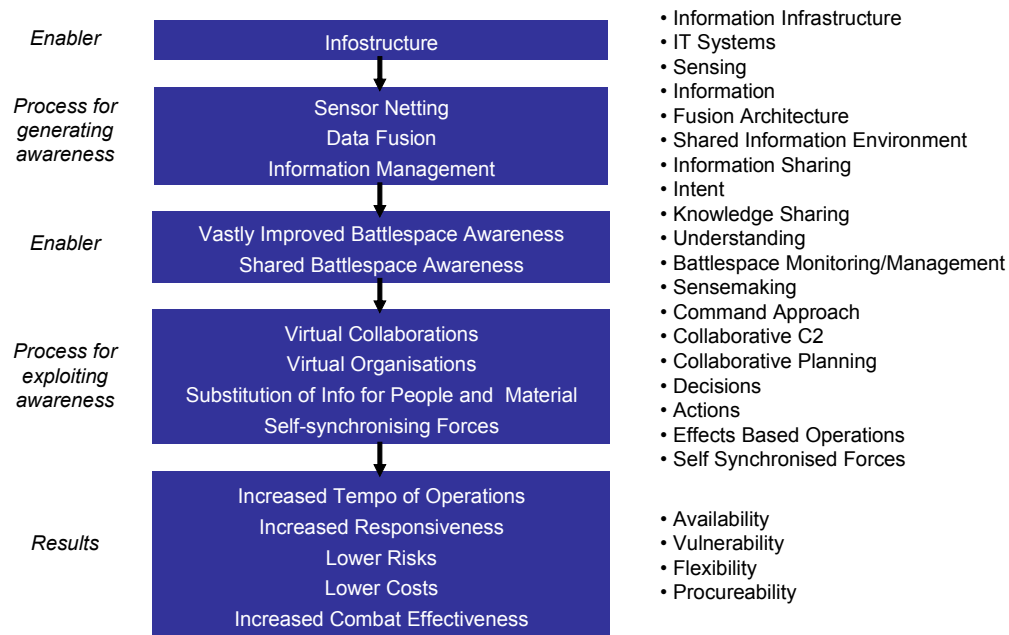


Figure 1: The Characteristics of NCW.

The six Themes, with their definitions, are shown in figure 2.

<b>Effects Synchronisation</b>	Achieving the desired effects through the synchronisation of activities within and between Mission Groups.
<b>Agile Mission Grouping</b>	Enabling the dynamic creation and configuration of task orientated Mission Groups that share understanding and that employ and coordinate available assets to deliver the desired effect.
<b>Dynamic Collaborative Interworking</b>	Enabling agile command and control within and between Agile Mission Groups through the ability to concurrently plan and execute operations in a way that is dynamic, continuous and synchronised. Thus, it allows all entities (including non-frontline MOD bodies, Other Government Departments, industry, academia and public service as well as military) to work together dynamically to meet changing mission needs.
<b>Shared Understanding</b>	Enabling each user to generate an understanding of the battlespace that is appropriate and adequate to their task and consistent with the understanding of others. This understanding covers the interpretation of the situation (current situation, its history, and potential developments of all battlespace participants) and of Command Intent (the effects and outcomes higher commands wants to achieve).
<b>Full Information Accessibility</b>	Enabling users to search, manipulate and exchange relevant information of different classifications captured by, or available in, sources internal and external to the battlespace.
<b>Resilient Information Infrastructure</b>	Ensuring information is managed coherently across the battlespace and that the potential for secure and assured connectivity is provided to all battlespace users.

Figure 2: The NEC Themes.

### The NEC Benefits Chain

The NEC Benefits Chain, figure 3, corresponds to the NCW Tenets [5]. As its title suggests, it is an attempt to indicate the unique NEC cause and effects chain that results, eventually, in “Better Effects” – the desired military benefit.

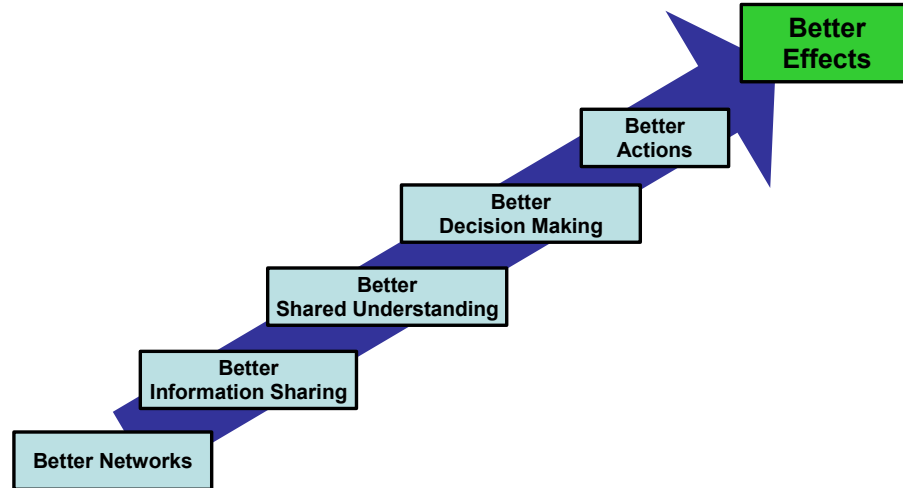


Figure 3: The NEC Benefits Chain.

The NEC Benefits chain asserts that:

Better networks provide better information sharing...  
... better information sharing provides better shared understanding ...  
... better shared understanding provides better decision making ...  
... better decision making provides better actions ...  
... and better actions provide better effects.

### Use Case: Using the current Themes and Benefits Chain

The application of the Themes and the Benefits Chain to one of the inquiries mentioned in the introduction (the case of the design of the new air-launched weapon system) shows their shortfalls

Whilst the system is still on the launch-rail it can still be thought of as part of the aircraft system, including its human operators. Once launched, however, the weapon system becomes autonomous. Taking each theme in order highlights the issues:

- Resilient Information Infrastructure. Obvious application to the weapon system. If it can continue to be part of the network then information can be passed to and from it in flight.
- Full Information Accessibility. Once networked the weapon system can access new targeting information, which could be used to correct its course mid-flight and relay information to the network information from its on-board sensors.

- Shared Understanding. Written from a very human perspective; one person sharing their understanding of the situation with another. Not applicable to the weapon system.
- Dynamic Collaborative Interworking. Again written with human decision-makers in mind. Not applicable to the weapon system.
- Agile Mission Grouping. Written from the perspective of decision-makers putting together components of military capability to form Agile Mission Groups. Not applicable to the weapon system.
- Effects Synchronisation. This is concerned with synchronising effects from multiple effectors. Synchronisation information could be passed to the weapon system as part of the Full Information Accessibility theme. This theme is applicable.

The application of the Benefits Chain mirrors that for the Themes. Being part of a Better Network will aid information sharing to and from the weapon system. The weapon system has no 'understanding' or 'decision-making capability' so cannot contribute to these parts of the chain. However, better information sharing could make the weapon system more accurate so the 'Better Actions' part of the chain is applicable, as is the Better Effects.

### **Extending the NEC Concept**

There are two conclusions that could be drawn from this exercise:

- NEC, and perhaps therefore NCW, are primarily about the human aspects of organisations, specifically the Command and Control component, and its use of information. In which case, you would expect automated systems to act at the extreme ends of the benefits chain, that is making networks and information and causing effects, but not the central part, which is concerned with cognition, understanding the situation and making decisions.

or

- The Themes and Benefits Chain need to be expanded to include autonomous machines. This would be particularly useful, enabling concepts such as swarming to be included.

This paper assumes the latter.

From this analysis there are three areas that need expansion:

- 'Understanding' and what this means in the context of autonomous vehicles and weapon systems.
- What it means to share 'machine understanding'.
- The involvement of autonomous machines and weapon systems in the decision-making process.

<b>Effects Synchronisation</b>	Achieving the desired effects through the synchronisation of activities within and between Mission Groups.
<b>Agile Mission Grouping</b>	Enabling the dynamic creation and configuration of task orientated mission groups that share understanding <i>and/or concepts</i> and that employ and co-ordinate available assets, <i>or enable their self-organisation</i> , to deliver the desired effect.
<b>Dynamic Collaborative Interworking</b>	Enabling agile command, <i>and</i> control and execution within and between mission groups through the ability to concurrently plan and execute operations in a way that is dynamic, continuous and synchronized. Thus, it allows <i>all users and</i> entities (including <i>autonomous machines</i> , non-frontline MOD bodies, Other Government Departments, industry, academia and public service as well as military) to work together dynamically to meet changing mission needs.
<b>Shared Concepts</b>	<i>Enabling entities within the battlespace to generate concepts of the battlespace that is relevant to their task, consistent with other entities' concepts and coherent with command intent and other users' understanding. 'Concept' in this context is an entity's formulation of its purpose, position and relation to other entities and users in the battlespace.</i>
<b>Shared Understanding</b>	Enabling each user to generate an understanding of the battlespace that is appropriate and adequate to their task and consistent with the understanding of other users <i>and entities' concepts (see Shared Concept Theme)</i> . This understanding covers the interpretation of the situation (current situation, its history, and potential developments of all battlespace participants) and of Command Intent (the effects and outcomes higher command wants to achieve).
<b>Full Information Accessibility</b>	Enabling users <i>and entities</i> to search, <i>push (including one-off broadcast and regular updates) manipulate</i> and exchange <i>(limited distribution push)</i> relevant information of different classifications (respecting security constraints) captured by, or available in, sources internal and external to the battlespace <i>and to manipulate such information (fuse or associate) whilst preserving and observing classification and provenance.</i>
<b>Resilient Information Infrastructure</b>	Ensuring information is managed coherently across the battlespace and that the potential for secure and assured connectivity is provided to all battlespace users <i>and entities.</i>

Figure 4: The Extended NEC Themes

The extended Themes are shown in figure 4, with the revisions shown in purple italic. The changes made for each theme are:

- Resilient Information Infrastructure. Very minor changes required to this theme. Only addition is to ensure that the term 'user' is extended to cover non-human users. The term 'entity' has been added for this purpose.
- Full Information Availability. As well as adding the term 'entity' to cover non-human information access, other additions have been made to extend the concept of information availability; specifically the concept of pushing information to users and entities (previously the wording suggested that only pull mechanisms were available) and expanding the term 'manipulate' to explicitly include information fusion.
- Shared Understanding. This theme has not been materially altered, but left to represent the sharing of understanding between users, i.e. humans. One small addition has been made to state that a user's understanding has to be consistent with other users' understanding **and with entities' concepts**. This idea of concepts will be covered in the next, new theme below.
- Shared Concepts. This theme is new and is there as a machine equivalent of Shared Understanding. The idea behind it has been borrowed from the world of Semantic Webs; where there is a commonly held 'conceptualisation' of an object that each member of the web 'stores' or 'think of' differently. Hence this common 'concept' can be used to share an understanding of the situation.
- Dynamic Collaborative Planning. The only change to this theme, beyond the cosmetic removal of the words 'and' and 'all', is to ensure that entities working together include 'machines'.

- Agile Mission Grouping. The only change to this theme is the inclusion of 'sharing of 'concepts' and the extension of co-ordination to include the possibility of self-synchronisation.
- Effects Synchronisation. No change.

Overall, apart from the addition of a new theme, which is the machine counterpart of a very human centric one, there is surprisingly little change to the NEC Themes. The major changes occur when we look at the Benefits Chain.

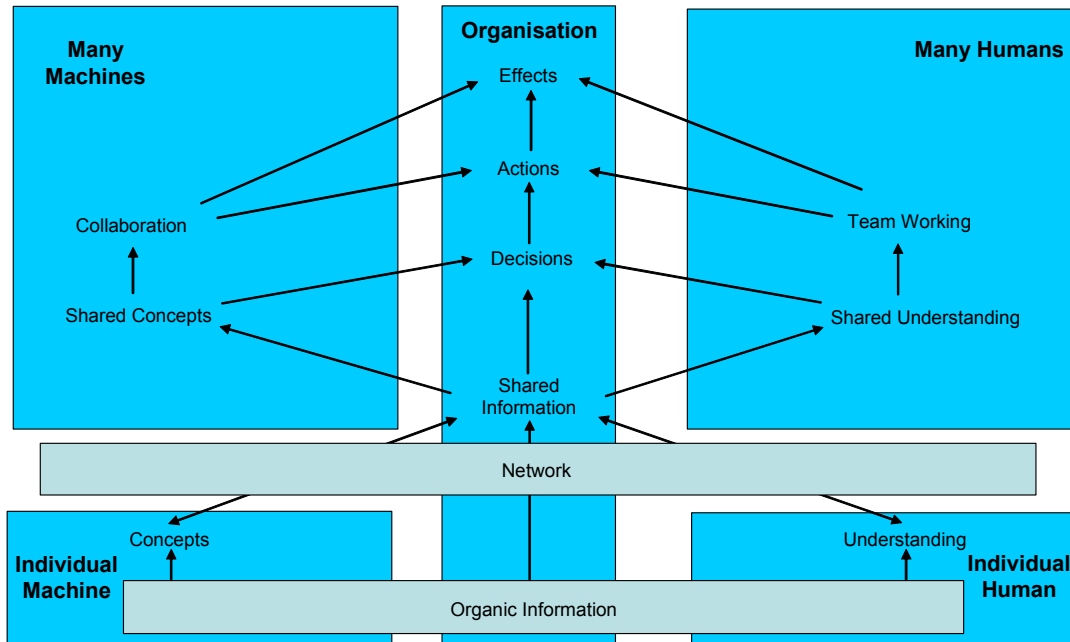


Figure 5: The Extended NEC Benefits Chain.

This, figure 5, is effectively a new Benefits Chain and it is possible, although very difficult, to see how it has evolved from the previous version. Hence it will be described in its entirety, not just the changes from the previous version. To meet the needs of the use case the Benefits Chain now has five parts (whereas before it only had one). These are:

- Individual Machine. An automated machine forms its own 'concepts' of the battlespace both from its own organic information sources and from information shared from other users and entities across the network.
- Individual Human. This is where an individual human gains an understanding of the battlespace through their own organic information sources and from information shared from other users and entities across the network. This is the counterpart of the 'Individual Machine'.
- Many Machines. This is where machines collaborate through the sharing of concepts.
- Many Humans. The counterpart of 'Many Machines', where many humans work in teams through a shared understanding.
- Organisation. This is where the decisions, actions and effects take place, and are all achieved through interworking of machines and humans that have shared concepts and that are collaborating in Agile Mission Groups.

Overall, reading from the bottom, the new Benefits Chain states that:

An individual's understanding and a machine's concepts, built from their organic information sources, are improved if information is shared via a network ...  
... the network also supports the sharing of concepts and understanding that will enable better decisions, collaboration and team working ...  
... which will lead to better actions ...  
... which will lead to better effects.

The final Benefits Chain, whilst not as simple as the previous one, is much richer and provides a better understanding of what NEC could become. It is also much closer in form to the NCW Framework [6].

### **Use Case: Using the new Themes and Benefits Chain**

Returning to our use case about re-designing the air-launched missile system. All the themes are now applicable. Rather than duplicate the impact of the Themes and the Benefits Chain, it is easier to explain the impact on the weapon system using the Benefits Chain only, but using the terms outlined in the Themes.

Starting in the area of the Individual Machine, the weapon system will define its part of the battlespace in terms of concepts that other users and entities can understand. This requires additional intelligence on the weapon (which will only already be there), but more crucially will require some common 'language' for concepts across the battlespace.

Once networked the weapon system will be able to share concepts with other users and entities, enhancing their concepts and understanding, and importantly improving its own – giving it a better 'model' of the target, objects near-by and importantly what other entities and users there are in its immediate battlespace.

These shared concepts will allow it to 'make decisions' about the actions it will take, in particular how it will collaborate with others. We can now see how 'swarms' of weapons could share concepts and synchronise to achieve a better effect than a number of individual, non-collaborating weapons could. For example, hitting the target from different angles determined whilst flying in, altering timings to minimise the after-effects of one weapon upon another or even neutralising itself should the target suddenly be deemed to be non-hostile.

### **Conclusion**

In conclusion, the extended Themes and Benefits Chain have provide us with a much richer understanding of what NEC could be, and in particular, how autonomous machines can become a part of NEC.

The Benefits Chain could become a much better way of assessing the NEC-ness of particular solutions and further work could be done to see how this corresponds to and effects the NCW Framework.

Finally, the new NEC Themes and Benefits Chain have proved very useful in understanding how to design future systems and will be used within QinetiQ to further the implementation of NEC.

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